VOLUME 79 SEPARATE No. 312

PROCEEDINGS

AMERICAN SOCIETY
OF
CIVIL ENGINEERS

OCTOBER, 1953

COMPOSTING OF GARBAGE AND SEWAGE SLUDGE

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Presented at
New York City Convention
October 19-22, 1953

SANITARY ENGINEERING DIVISION

(Discussion open until February 1, 1954)

Headquarters of the Society
33 W. 39th St.
New York 18, N. Y.

PRICE $0.50 PER COPY

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This paper was published at 1745 S. State Street, Ann Arbor, Mich., by the American Society of Civil Engineers. Editorial and General Offices are at 33 West Thirty-ninth Street, New York 18, N. Y.

COMPOSTING OF GARBAGE AND SEWAGE SLUDGE

Eric Eweson

Modern civilization is beset by two seemingly unavoidable evils. One is improper disposal of the wastes from our cities with resulting pollution of air, water and surrounding land. The other is agricultural soil impoverishment with its well-known consequences of floods, erosion, dust bowls and deserts, the more obscure effects of which are impaired health and resistance to disease in plants, animals and humans.

We are proud of our progress in sanitation, but we have as yet no better ways to dispose of the waste matter than by burning or dumping in nearby waters or dumping grounds. In fact, many of our cities are well on the road to polluting themselves out of existence. Even where sewage-treatment plants exist the resulting sludge residue usually ends up on unsightly dumps, as does most of the garbage, creating favorable breeding grounds for flies and rats.

Even more important than the pollution, however, is the fact that all of the organic wastes are sorely needed to restore the land. Actually the word "waste" is incorrect, because these are the by-products from the life process, not to be wasted but necessary to maintain proper balance between growth and decay for high soil fertility and a vigorous life cycle. In fact, the proper solution of our municipal waste disposal problem could not fail largely to solve also our still more serious problem of declining soil fertility.

My proposal for solving this two-faced but single problem of our urban civilization is to convert the organic wastes into humus. From the soil these wastes have come, to the soil they must be returned in order to maintain true soil fertility. The process is called composting and was a common practice in certain parts of China and India as far back as four thousand years ago. While the benefits of compost as a fertilizer have never been in dispute, the making of it by the old methods takes too much time and labor to be practical in modern times.

These obstacles have now been overcome. Composting of municipal and industrial wastes of organic origin can be accomplished by a new process in as many days as it requires months to produce compost by old methods. It can be done on a large scale industrial basis, with a minimum of manual labor, at low cost and with no offensive odors. The end product is a finely granular, blackish compost, in appearance and odor like rich fertile topsoil.

In a proper composting process remarkable precautions are provided by nature to prevent transfer of disease from higher forms of life via lower back again to the higher - that is, from man via soil and plant back to man. Penicillin and streptomycin are both products of soil microbes which abound in humus and exemplify nature's delicate yet powerful protective devices.

A special safeguard against transfer of disease is provided by the high temperatures developed by the microbes in this modern process - temperatures of 160 to 170 degrees F. This is a most reassuring margin of safety when we consider that the cysts causing amoebic dysentery, more resistant to heat than any other pathogenic organism, are completely destroyed at 122 degrees F.

To fertilize land with raw, undecomposed city waste is an indefensible practice. Warnings against the consumption especially of uncooked vegetables grown in this manner are well founded, for such vegetables may transmit dysentery and typhoid.

Digester Composting Process

This process for the manufacture of compost is breifly as follows: The organic raw materials and a quantity of acclimatized culture of soil microorganisms are mixed, shredded and deposited in a "digester" of novel design. This is a decomposition chamber of some 5,000 cu. ft. capacity equipped for the supply and withdrawal of air in closely controlled, variable quantities. Too much air must be avoided as carefully as too little air, the exact quantities depending on the intensity and stage of decomposition.

For the operation of the micro biological process in its various stages of development and to avoid the high compression of the decomposing material, which would result from piling it up some thirty feet, the digester is divided into five separate compartments. Of these the upper four are fermenting zones and the bottom one the unloading zone. All of these zones require different degrees of aeration and have different temperatures and carbon dioxide concentrations. In fact it is by the reading of thermometers and CO^2 meters that the entire process is conducted and controlled.

It is important also that in the parts of the digester where maximum microbic activity is desired the air supply consists not of fresh air from the atmosphere but of air similar to the kind found in fertile soil, which is saturated with moisture and contains from 10 to 50 times as much carbon dioxide as does atmospheric air. Such air becomes available in the process through the microbic activities and can be distributed as required. With moisture the carbon dioxide forms carbonic acid, which aids in rendering the organic wastes assimilable to the microorganisms in the decomposing mass, just as happens in fertile soil.

The decomposition, which is an aerobic fermentation process, proceeds continuously, the digester being charged with raw materials (canning, tobacco, sugar, cotton, feed mill, fish and packing house wastes; leaves, garbage, sewage sludge; farming and truck-garden wastes) at the top and the finished compost being discharged at the bottom.

For a more detailed description of the process let us assume that it has been in normal operation for some time and that thus during the previous six days the digester has been charged with about fifteen tons of raw materials per day, of which approximately one ton has been bacterial culture. The fourth fermenting zone - the lowest - will then contain finished compost, ready for transfer to the unloading zone. This material, during the week it has taken to reach the final stage of development has undergone a succession of various microbic evolutions as indicated by changes in temperature, carbon dioxide concentration, moisture and appearance. From about 80 F. the material will have heated up to about 170 F. The carbon dioxide of the air in the material will similarly have increased from about 0.05% to as high as 15%, or 300 times, sometimes in the short time of 24 hours. This is such high carbon dioxide concentration that the microbic activities will have a tendency to turn from the desired aerobic to anaerobic from lack of oxygen. This must not be permitted to occur and can easily be prevented by proper use of the special aeration facilities in the digester.

The air for the requirements of the process is introduced at the bottom of the digester with sufficient pressure to penetrate the decomposing mass

through all the zones, about 30 feet in height. As the air is forced upwards it gathers moisture, carbon dioxide and heat, which are characteristics of the air that are desirable, and increasingly so as the higher levels of the mass are reached. The most recently added material in the top zone has enough air from the shredding and mixing operations to sustain aerobic development for some 12 to 24 hours. The requirements in this zone are therefore a minimum of air and oxygen, but a maximum of carbon dioxide and heat, which is provided by the utilization of air that has passed through all the lower zones and there acquired those characteristics.

The atmospheric air introduced at the bottom of the digester for aerating the decomposing mass contains only about 0.04% carbon dioxide. Already after having penetrated the lowest fermenting zone - the fourth - such air will have a carbon dioxide content of 1 to 2%. From the next higher zone it will have some 2 to 4%, reaching the top zone with as much as 8 to 10% carbon dioxide. With the increase in the temperature and moisture content of the air from passing through moist material with temperatures of 150 to 175 degrees F. we now have air conditioning of the kind that the microbes like and would themselves develop if given the time and proper conditions. The material in the top zone is, of course, especially benefited, having almost immediately been turned into an ideal environment for intensive microbic activities. The high content of carbon dioxide is forming a continuous supply of carbonic acid, which is needed to aid in dissolving non-water soluble nutrients for the microorganisms. Otherwise they would be limited to the few water soluble nutrients contained in the compost raw materials.

It is, however, in the middle zones of the digester where the most intense microbic activities occur and where the material undergoes the most marked changes. Greater quantities of air with more oxygen and relatively less carbon dioxide are required for these zones than for the top zone, and such air can always be provided as explained above.

In the lowest zone, the fourth, the microbic activities are slowing down by reason of less nutrients. This natural development is encouraged in the process by letting larger quantities of air pass through this zone than required by the microorganisms, which has a depressing effect on them. The decomposed material thus becomes stabilized and slightly dried out and is now ready for transfer to the unloading zone as finished compost. After the compost is discharged from the digester it goes through a final aeration treatment before being dried, screened and bagged.

The provisions for aeration control are simple and effective. Under each of the grid sections which separate the zones are adjustable air vents. Since under normal operations less and less air is needed as the higher zones are reached it is necessary to bleed off the surplus air. This can be accomplished very efficiently thanks to the unusual bridging characteristics of the decomposing material, which also contracts rapidly in volume when in repose. These traits make the material above the grids bridge between the grid members as the material below the grid contracts and sinks. Empty spaces or air reservoirs are thus formed under each grid, from which surplus air can be released through the adjustable air vents so as to suit the varying requirements in the various zones.

If inadequate quantities of air should be reaching a certain zone, as would be indicated by a relatively too high temperature or too high carbon dioxide concentration, it is merely necessary to reduce the outlet of air through the vent under the grid section which supports this zone of material. As a result more air will be forced up through this zone and the situation quickly corrected.

The microbic developments in the process are caused by aerobic and facultative aerobic fungi, bacteria, and actinomycetes. The exact sequence of these various activities in composting is only known to a limited extent as yet, and they will vary considerably depending on slight changes in materials processed, moisture, and pH conditions.

The principal advantages of composting in closed digesters over pits and piles are better control of air and better retention of moisture, which latter avoids the need for adding water to compensate for the rapid loss of moisture in open piles. Anybody who has tried making compost in piles knows that outside material exposed to the air remains undecomposed. This is because such material is aerated beyond the point where the microbic activities can be sustained. Preservation and uniformity of heat in the large quantity of decomposing material is also a great advantage of big, well insulated digesters. Ease of handling the material, reduced requirements of space and complete absence of objectionable odors are other factors in favor of closed digesters. Under proper operation, a digester does not develop any liquid residue with the consequent loss of valuable nutrients. No nitrogen should be lost in the process unless the carbon-nitrogen ratio is abnormally low. The transfer of material from one zone to a lower, which corresponds to "turning" of compost piles, is brought about by breaking the bridges formed between the grid members by the material, as a result of which the material falls down into the next lower zone. The bridging is broken by specially designed cutter arms, operated from the outside of the digester.

Ground limestone may be used to maintain neutral reaction during the process. In order to compensate for the mineral deficiencies which are likely to occur in our present organic waste materials, other ground rock materials may also be added. They will be acted upon by the carbonic acid and the microorganisms with the result that the minerals will be liberated and rendered available as plant food. But no chemicals are used either as food or as stimulants for the microorganisms.

Finished compost passes through a four to six-mesh screen, leaving about 10 per cent tailings which are used as culture and thus returned to the processing. The composting process is completed in a cycle of seven days. It is adaptable to high degrees of mechanization and automatic controls, and causes no objectionable odors.

Except for starting operations in a new compost plant, for which the bacterial culture is supplied by another plant, the process does not require any additional supplies of culture. Instead, the operations of these compost plants are based on their own continuous development and acclimatization of culture, which never needs to be renewed from the outside, even if operations should be interrupted for a considerable length of time. The operation of the plants does not require technically trained personnel. High school chemistry is ample background of training to become a plant manager.

Compost From Municipal Wastes

In order to manufacture compost from city refuse by this process in closed digesters, it is necessary that the garbage be "assorted" so that the kitchen wastes and spoiled foods from markets or the like are reasonably free from paper, glass, crockery, ashes and metal scrap. Such assorting is done by the householders in thousands of American cities, notably in all places where the garbage is used as pig feed. Tin cans may either be put with the kitchen wastes or with the other refuse. In the former case the tin cans are taken

out in the compost plant by a magnetic separator. Small quantities of paper with the kitchen wastes do not matter, but newspapers, magazines and cardboard should be bundled and tied and placed alongside the refuse cans by the householders.

For cities with inadequate incinerator facilities it is worth noting that compost manufacture will relieve the incinerator of the wastes which are difficult to burn. The resulting gain in incinerator capacity is considerably more than the quantity of wet garbage going to the compost plant. Other advantages will be lower operating and maintenance costs for the incinerator from burning mainly dry refuse, and less objectionable odors as they are almost entirely derived from wet garbage incineration. There are no objectionable odors from compost manufacture as immediately after the garbage has been mixed and inoculated with the bacterial culture in the shredding process such odors are eliminated. The mechanical equipment is so designed that if the garbage is received at the compost plant during the first half of the working day all of it can be shredded, inoculated and deposited in the digester that same day.

The building for a two-digester compost plant occupies a space of about 40' x 120' and correspondingly less in case of a two-story building, which is somewhat preferable from an operational point of view. The necessary working force is six men and the plant manager.

Sludge cake from municipal sewage disposal plants should, of course, also be disposed of by composting instead of being dumped and burned. The quality of the compost will be improved by adding sludge cake to garbage.

The assorting of city refuse and segregation of kitchen garbage mentioned above as a prerequisite for composting in digesters will greatly facilitate economic salvaging of paper, cardboard, tin cans, rags, etc. A modernly equipped plant for such salvaging should result in sufficient revenues and savings to the cities to amortize the cost of the plants in ten to fifteen years.

By the manufacture of compost from the garbage and salvaging most of the other refuse there will remain but very little to burn or dump and nothing to cause objectionable odors, rat or fly problems.

In the utilization of garbage for the manufacture of fertilizers, we must clearly distinguish between composting and stabilization processes. While the stabilized product is a valuable soil supplement, produced by the grinding, aerating and drying of garbage, it is primarily an undecomposed product, which in order to be utilized as plant food first has to undergo decomposition in the soil by more or less the same micro-biological process that produces compost in piles or digesters. A stabilization process is rapid, taking anywhere from a few hours to one day. Compost manufacture requires much longer time. With this process, which can best be described as a mechanized Indore process, the necessary time has been reduced to seven days, which is attained when the initial culture has been properly acclimated, usually in the course of four to six weeks. Such rapid composting has become possible mainly because of the described, novel arrangements for near optimum biological developments, but also because the process is interrupted when about 90% of the material is properly decomposed, at which time the coarse, still partly undecomposed portions of the mass are screened off. While this cuts the time of the processing considerably more than 10% it is still much more important in order to obtain a sizable, continuous supply of microbic culture in the best stage of development and potency for inoculation of new compost raw materials.

Can Large Quantities of Compost Be Sold?

The great need for organic fertilizers to rehabilitate our worn soil and to maintain the high yields and high quality crops that this country needs, is now recognized by almost all agronomists.

Even a firm advocate of chemical fertilizers like Dr. Firman E. Bear, Chairman of the Soils Department of Rutgers University, one of our top soil scientists, writes as follows on this subject:

> "***** fertilizers alone, no matter how heavy the application, will not meet the requirements for soils that are producing cultivated crops. Soils must be fed with organic matter in larger amounts than the roots and residues of such crops can provide. This requires manure and well chosen mixtures of sod and cover crops. If, in addition, we can develop means of producing supplemental compost from city refuse, or by any other means, so much the better. In my opinion, we should lend assistance to efforts that are designed to avoid waste of organic materials. It might well pay to subsidize the processing of such organic wastes as can be made available for use on intensively cropped land." ("The Wrong Turn" by Dr. Firman E. Bear in the Journal of Soil and Water Conservation, April 1951.)

The size of the fertilizer market can best be judged by the facts that for our harvested area of about 350 million acres we are now using just about 20 million tons of fertilizer per year, which is about twice as much as ten years ago. This works out at roughly 100 pounds per acre per year, which, of course, is utterly inadequate. Many times as much is needed and a great part of this increase must be in the form of high grade organic fertilizers like compost in order to make up for the inevitable loss of organic material in the soil, which results from all cropping, especially on land fertilized with chemicals to yield big harvests.

In order that compost may meet the requirements of our modern agriculture and thereby also help solve our municipal waste problems, the compost must in my opinion be of much higher quality than the presently known product. Developments will, I am sure, have to follow along the lines of chemical fertilizers towards higher concentration of plant nutrient content in order to justify the relatively high costs of transportation, bagging and other handling charges, including costs of applying the compost by the farmer to his land.

Many organic enthusiasts regard compost as high grade if it contains $\frac{1}{2}$ % each of nitrogen, phosphorus and potassium (NPK formula of $\frac{1}{2}$ - $\frac{1}{2}$ - $\frac{1}{2}$) calculated on its usual moisture content of about 50%. Such low grade compost is too costly to handle. Instead it should have four to six times as high NPK content on a 25% moisture basis. Recent experiments have shown that still higher grades can now be made by certain modifications of the process I have described, the resulting compost analyzing as high as $2\frac{1}{2}$ - 5 - 3 for NPK content on 25% moisture basis. Considering that these plant nutrients are practically non-leachable, while those in chemical fertilizers are known to be largely lost by leaching or insolubilizing before they can be absorbed by the plant roots, it is safe to state that said high grade compost would compare favorably in effective NPK content with chemical fertilizers of as high concentration as 5- 10 - 6. In addition this compost can be guaranteed to contain all of the other thirty or more mineral elements that are now known to be of fundamental importance for vigorous life. The further facts that compost is teeming with beneficial microorganisms to the extent of several billion per

ounce of compost; that compost is non-toxic to plant and soil life so that it cannot burn seeds or tender roots; and that compost in contrast to chemical fertilizers contains no inert fillers but is of great value for the soil in its entirety, are other points in favor of compost.

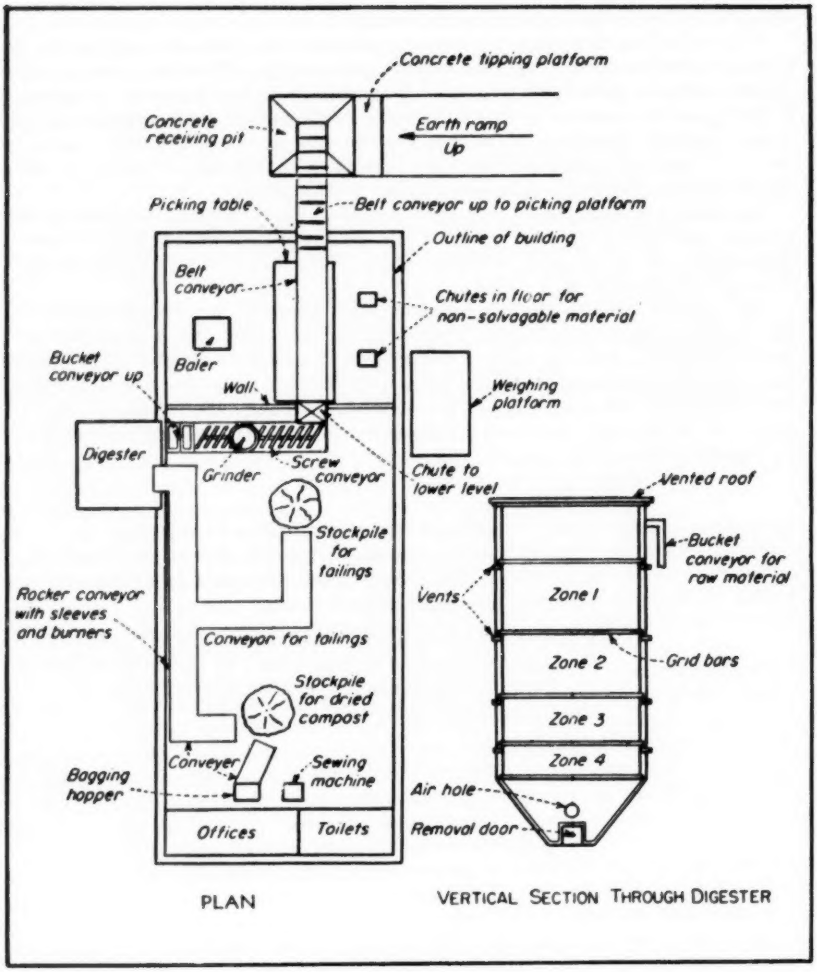
The belief that only high grade compost makes for economic operations is confirmed by recent experiences in Zaragoza, Spain. While the original municipal compost plant of conventional European design in that city, completed in 1949, has been unable to sell but a very small part of its production of low grade compost, the newer plant of described design, 100 yards away, using the same kind of garbage for the manufacture of high grade compost, is selling its entire production at several times higher price.

To avoid misunderstandings I wish to stress that chemical fertilizers, of course, cannot be done away with. While great benefits would result from large scale use of compost, we also need and could then better afford to use chemical fertilizers on the land.

The capital investment for a compost plant using the process described and having a capacity of 25 tons of kitchen garbage daily (two digesters) is about $100,000. A 50 ton daily capacity plant would cost about $150,000, with corresponding savings for larger plants. These compost plants are, however, self supporting and should result in sufficient revenues and savings to the cities on incinerating and dumping expenses to amortize the entire cost of the plants in five or ten years.

Acknowledgments: The Composting Process described is known as the Frazer-Eweson Digester Process. It was developed by the author. The license rights are held by Frazer-Eweson Company, Newport, Rhode Island.

Parts of this article appeared under title of "Profitable Garbage Disposal by Composting", by the same author in the Bulletin of Engineering and Architecture No. 29, University of Kansas, 1953.



Schematic Plan of a Frazer-Eweson Compost Plant for One Digester
(Engineering News Record, November 1952)